TECHNICAL PAPER 366 LEVEL II

(12)

USER PERFORMANCE UNDER SEVERAL AUTOMATED APPROACHES TO CHANGING DISPLAYED MAPS

Franklin L. Moses and Richard E. Maisano

HUMAN FACTORS TECHNICAL AREA

U. S. Army
Research Institute for the Behavioral and Social Sciences

June 1979

U. S. ARMY RESEARCH INSTITUTE

FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency under the Jurisdiction of the Deputy Chief of Staff for Personnel

WILLIAM L. HAUSER
Colonel, US Army
Commander

JOSEPH ZEIDNER
Technical Director

NOTICES

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
(9) Technical Paper 366

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER
(14) ARI-TP-366

4. TITLE (and Subtitle)
(6) USER PERFORMANCE UNDER SEVERAL AUTOMATED APPROACHES TO CHANGING DISPLAYED MAPS.

5. TYPE OF REPORT & PERIOD COVERED
--

6. PERFORMING ORG. REPORT NUMBER
--

7. AUTHOR(s)
(10) Franklin L. Moses [redacted] Richard E. Maisano

8. CONTRACT OR GRANT NUMBER(s)
--

9. PERFORMING ORGANIZATION NAME AND ADDRESS
U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, VA 22333

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
(16) 2Q162722A765

11. CONTROLLING OFFICE NAME AND ADDRESS
Army Deputy Chief of Staff for Personnel
Washington, DC 20310

12. REPORT DATE
(11) Jun[redacted]79

13. NUMBER OF PAGES
30

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
---
(12) 35 p.

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

---

18. SUPPLEMENTARY NOTES

---

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

075 000000

User/computer interaction
Graphic display applications
Computer graphics
Display design
Map displays
Military systems
Tactical displays
Tactical Operations System (TOS)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Performance in a route selection task was used to evaluate automated methods for changing from one displayed segment of a map to another. Participants were 24 Army officers, who chose successive 6.75 x 9 km map segments (1:50,000 scale) for solving 12 problems. Each problem requested the fastest road route between pairs of cities within a 60 x 81 km region. Participants solved problems by electronically marking road routes across map segments. Methods for changing map segments were (a) continuous map scanning and (b) discrete map segments using three different amounts of border overlap (0%, 25% and 50%). Results

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified 408 010

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. (continued)

showed that different map change conditions did not significantly affect the quality of routes chosen. The least time for problem solutions occurred when map segments with 50% overlap were used, although 25% overlap produced similar data. Designers of map display systems for the military could optimize user performance time with discrete map segments that overlap by about 25%.

TECHNICAL PAPER 366

USER PERFORMANCE UNDER SEVERAL AUTOMATED APPROACHES TO CHANGING DISPLAYED MAPS

Franklin L. Moses and Richard E. Maisano

Raymond C. Sidorsky, Team Chief

Submitted by:
Edgar M. Johnson, Chief
HUMAN FACTORS TECHNICAL AREA

Approved By:

Frank J. Harris, Acting Director
ORGANIZATIONS AND SYSTEMS RESEARCH LABORATORY

Joseph Zeidner
TECHNICAL DIRECTOR

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, Virginia 22333

Office, Deputy Chief of Staff for Personnel
Department of the Army

June 1979

Army Project Number
2Q162722A765

Tactical Operations
& Displays

FOREWORD

The Human Factors Technical Area of the Army Research Institute for the Behavioral and Social Sciences (ARI) is concerned with the demands of the increasingly complex battlefield for improved man-machine systems to acquire, transmit, process, disseminate, and utilize information. The research focuses on the interface problems and interactions within command and control centers and concerns such areas as topographic products and procedures, tactical symbology, user-oriented systems, information management, staff operations and procedures, and sensor systems integration and utilization.

One area of special research interest involves the application of automated display systems to analyze and model the dynamic battlefield. Graphic display methods, including aids and modeling concepts, potentially can enhance the ability of the command staff, at both division and corps levels, to make timely and comprehensive analyses and projections of battlefield information. The present research evaluated methods for using interactive computer graphics to show map displays. The research is part of a continuing effort to provide the command staff with improved capability for coping with the modern battlefield's increased flow of tactical events, by developing methods using computer graphics to transmit information. Such research provides a necessary technological base for effective design of the user/systems interface.

Research in the area of graphic analysis of tactical dynamics is conducted as an in-house effort augmented by contracts with organizations selected for their specialized capabilities and facilities. These efforts are responsive to general requirements of Army Project 2Q162722A765.

The present research is also related to special requirements of the U.S. Army Combined Arms Combat Development Activity, Fort Leavenworth, Kans., and the U.S. Army Intelligence Center and School, Fort Huachuca, Ariz. Special requirements are contained in Human Resource Needs 78-100 (ADP Methods for the Utilization of Analytic Aids and Logic Models in Intelligence Processing) and 78-151 (Staff Methods and System Aids for Battle Management Processing and Problem Solving Aids in Tactical Automated Systems).

Joseph Zeidner

JOSEPH ZEIDNER
Technical Director

USER PERFORMANCE UNDER SEVERAL AUTOMATED APPROACHES TO CHANGING DISPLAYED MAPS

BRIEF

Requirement:

To evaluate the impact on task performance of two automated methods for changing from one displayed segment of a map to another.

Procedure:

Participants were 24 Army officers, who used successive 6.75 x 9 km map segments (1:50,000 scale) to determine the fastest road route between two points in a 60 x 81 km region. Each road route problem specified a city of origin, a destination city, and the relative map coordinate locations of each. Two types of presentation methods were evaluated: (a) continuous map scanning and (b) discrete map segments using three different amounts of border overlap (0%, 25% and 50%). Using the continuous method, participants could explore the map and stop on any area of interest. The discrete method limited the amount of new map area that could be accessed in any single change. Participants solved problems by selecting map display changes and electronically marking chosen road routes. Performance was measured for quality and speed on each of 12 problems divided among presentation methods.

Findings:

Problems took the least time when discrete map segments with 50% overlap were used; however, 25% overlap produced similar data. The participants who changed map segments more often took less time to work problems. Overall, different map change methods did not significantly affect the quality of routes chosen.

Utilization of Findings:

The usefulness of automated displays for showing maps is limited by display resolution and size. One map segment after another has to be shown in order to display details over any large area. To optimize user performance time, the designer of a military map display system should begin with discrete map segments that overlap by about 25%. The percentage can vary somewhat without affecting performance. The 25% guideline for overlapping adjacent map segments is based upon both user performance and preference; however, this approach requires fairly frequent map changes, which increases demands on hardware.

USER PERFORMANCE UNDER SEVERAL AUTOMATED APPROACHES TO CHANGING DISPLAYED MAPS

CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

USER PERFORMANCE UNDER SEVERAL AUTOMATED APPROACHES TO CHANGING DISPLAYED MAPS

Topographic information is a major component of understanding battlefield situations. Maps provide the background for plotting unit positions and are required for analyzing the likely effects of terrain, vegetation, and weather on unit movements, important offensive/defensive positions, and potential avenues of approach. The feasibility of automated displays for tactical analyses depends upon user-efficient methods for viewing automated maps. Hardware for such displays has received some consideration (Cannon, 1973, 1977), but display resolution limits the size of map segments that can be shown. The present research evaluated user performance under two different methods for changing from one displayed map segment to another.

There are at least three approaches for developing automated map displays. One approach is to determine what detail (if any) can be eliminated or reduced to make present maps more compatible with current display technology (Granda, 1978). A second approach is to provide for changing the scale of a displayed map so that more or less detail can be presented, as required. A third approach, considered here, is to sequentially display map segments at a common scale with enough detail to satisfy many of the user's needs.

A potential application of automated graphics is the determination of optimal traffic routes. This application can be used to evaluate alternative methods for changing displayed map segments. An Army officer choosing a route manually may require several hours for a thorough solution, depending on problem complexity. Numerous hard-copy maps, which cover a large geographical area and emphasize various aspects of terrain and road characteristics, are often required. Selecting the optimum route involves close examination of several similar possibilities and detailed consideration of road types, population densities, and other obstacles to quick travel. A computer display system could make map information more easily available without requiring extensive hard-copy map storage.[1] In addition, criteria for performance on route selection problems with automated map displays can be obtained from computer algorithms designed for such tasks (Cooper et al., 1974).

---

[1]Other automated aids could include distance/time calculations, record keeping, prompts, etc. However, the focus of the current research is on the display of map information as a basic feature of such systems.

BACKGROUND

Use of a computer for displaying maps is a potentially valuable component of both military and nonmilitary information retrieval systems (Berman et al., 1977; Carlson et al., 1974; Cooper et al., 1974; Moellering, 1977). A major problem, however, is that state-of-the-art displays are limited in screen size and resolution. (The availability of an adequate map data base is not considered in this paper.) The potential detail required for displays is illustrated by conventional hard-copy maps, which are designed not for accurate presentation by electronic devices but for reading by the human eye. For example, a single grid box (about 4 cm^2) of a standard 1:50,000 scale military map requires an entire 525-line color television screen to show the smallest printed details. For many tasks, users require the display of a larger map area in more detail than is electronically possible. The likelihood is that electronic display resolution and size will only slowly catch up with such user needs. Therefore, methods are needed for displaying segments of maps without unduly isolating one segment from another. These methods must help users to integrate individual map displays into a cohesive picture of the area being studied.

The problem of using map segments for convenient presentation is not new. Hard-copy maps represent only subdivisions of larger areas. For many tasks, the user often needs several map sheets. As an example, for long-distance driving in the United States, a traveler must use several State and city highway maps. When using different maps, the user needs map-to-map continuity of various features, including roads and topography. Several ways of maintaining orientation from one map sheet to another are available: one map sheet can be placed next to another, related points can be marked on adjacent sheets, sheets can be flipped back and forth, and so on. Looking at map sheets one after the other, however, adds the burden of remembering related factors on adjacent sheets.

Previous research suggests that integrating information across the boundaries of map sheets presented sequentially requires considerable cognitive processing time (Shimron, 1975; Layman, 1968). Shimron (1975) asked participants to learn a simple line-drawing map. The map showed a river, a mountain range, 3 major roads, and 10 cities. Cities were located at road intersections, and roads were given names. Participants remembered local connections between map elements (e.g., most northern city; city in the mountains) after only a short 6-minute learning period. Overall integration of map units, however, such as naming the order of cities along a particular road or remembering the orientation between cities (e.g., what city is south of city A?), produced only 50% accuracy after 12 minutes of learning time.

Research by Layman (1968) supports the idea that map segments are harder to use than single maps of an entire area. Layman asked participants to use a map for locating an aerial photograph and the position of a particular photographed object. The time to perform the tasks increased significantly when participants had to use map segments rather than a single map sheet. Layman suggested that the primary problem occurs when the area of interest lies along the border of two adjacent map segments that cannot be viewed simultaneously. The user requires more time for map reading when forced to depend on memory for a map segment not in view.

A computer display of map information may be considered the electronic equivalent of using a hard-copy map segment. The ease with which map information can be retrieved and the provision for continuity of one map display with another are important human factors issues. Using discrete sources of maps in the form of slides is a convenient way to store and retrieve such information. However, the user may have trouble combining information across boundaries of sequentially presented map segments.

One possibility for improving map presentations is to allow some percentage of map area to overlap between adjacent segments. Such overlap may provide better user orientation than nonoverlapping segments. Both overlapping and nonoverlapping map segments are referred to in this paper as "discrete" presentation methods. An alternative, referred to in this paper as a "continuous" method, is to allow continuous map scanning where the display is a "window" for a large map area. The user can explore the map and stop on any area of interest. Intuitively, the continuous method might seem to be the most flexible and promising for the future. The user, however, might be served more quickly, less expensively, and equally well by discrete map displays. The purpose of this research was to test the ease and accuracy of map use with (a) displays of discrete predetermined segments with both overlapping and nonoverlapping areas and (b) displays allowing continuous map scanning.

METHOD

Participants

Participants were 24 Army officers, 03 to 06 in rank, with military map reading experience.

Design

The task was to use 6.75 x 9 km map segments (1:50,000 scale) within a 60 x 81 km region to determine the fastest road routes between cities. Participants were required to solve four sets of three problems (Appendix A). Each problem set was solved with one of four display presentations: continuous map scanning or viewing of discrete segments (see Figure 1) with 0%, 25%, or 50% overlap. Map scale was kept constant, and standard military Universal Transverse Mercator (UTM) coordinates were used as a

reference system. Each problem specified a city of origin, a destination city, and the relative map locations of each, using the general form: "You are presently at (city name, map coordinates) and have to go to (city name, map coordinates). What roads would get you there fastest?"

Participants were divided into four groups of six people each. Each of the six participants in a group was assigned randomly to one of four unique sequences of problem sets and map change methods forming a Greco-Latin square design (Winer, 1971, p. 719). The counterbalanced design controlled for time delays, practice effects, and presentation differences in the problem sets, and map change methods.

Apparatus

Figure 2 shows the principal apparatus. The display generator consisted of a computer graphic system (Anagraph by Datadisc, Inc.[2]), a color television camera (GBC CTC 3XP), and a map. The computer system generated cathode ray tube (CRT) displays of all alphanumeric and graphic information except the map. The map image was transmitted to a display by cable from a color television camera. The stationary camera framed a segment of the entire map, which was mounted on a 4 x 6 foot movable vertical surface. This surface was equipped with a separate motor, clutch, and drive system for movement along both x and y axes; digital encoders to read the board's position on each axis; and a control system interfaced with the computer.

At the work station (see Figure 3), participants had two 19-inch raster scan color CRTs (Conrac, Inc.), a keyboard, and a trackball, all of which were interfaced with the computer. The left-hand CRT showed map segments with roads marked by black dots at intervals along their lengths. The right-hand CRT (see Figure 4) showed two types of information: (a) the top of the screen presented the problem, and (b) the rest of the screen showed a grid and coordinate system representing the total map area of interest. When the left screen showed a map segment, the right screen used a red rectangle to show a segment's location on the grid and an arrow to show the direction of the change in displayed map area. Dashed lines and letter codes corresponded to the displayed map's coordinate system. The only other materials provided to participants were a booklet of instructions, a participant-experimenter intercom, and pencil and paper for notes. The experimenter had CRT monitors linked to the participants' displays.

---

[2] Trade names are used only for precision in reporting and do not constitute endorsement by the Army or ARI.

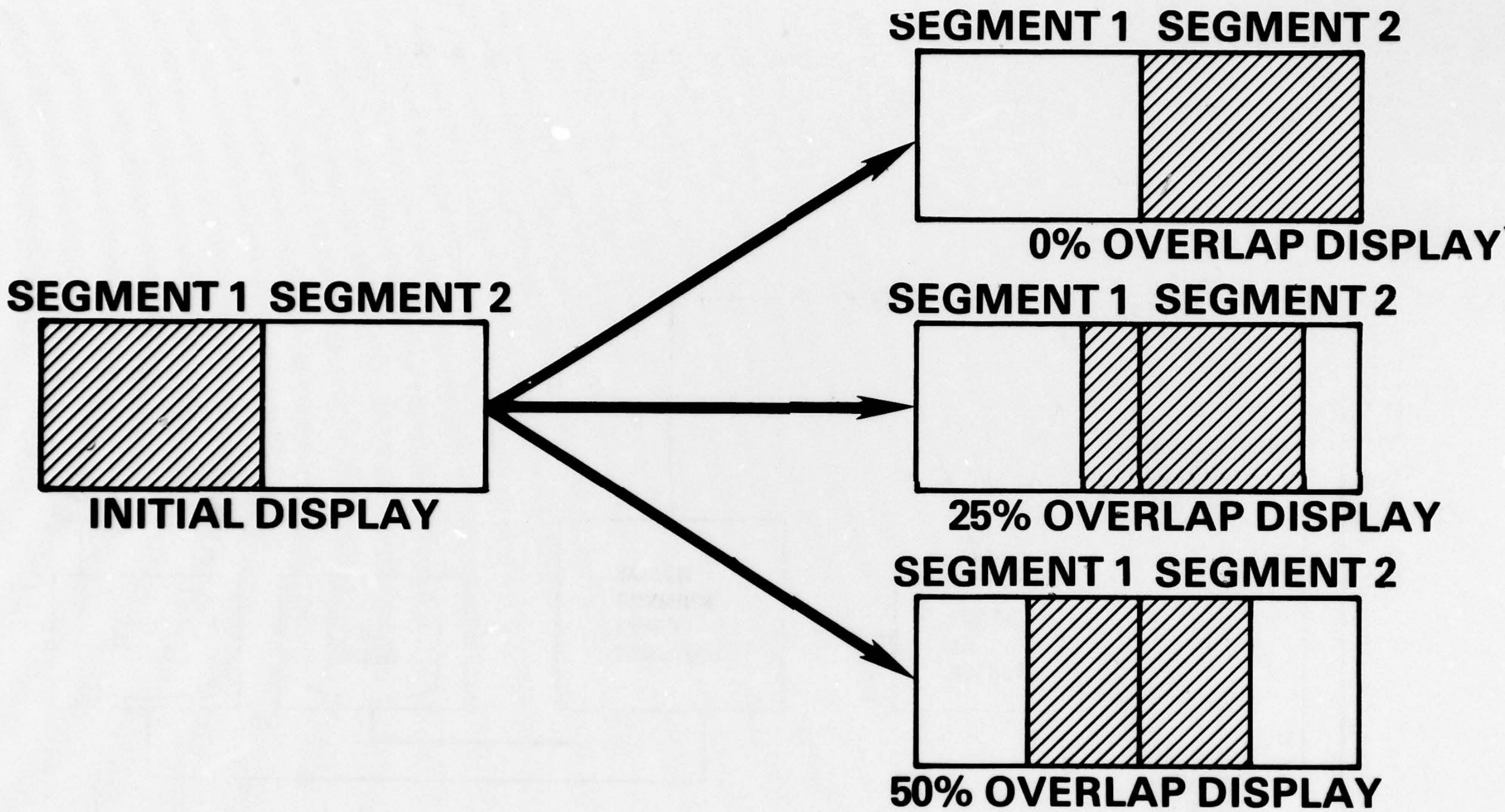


Figure 1. Overlap parameters for two adjacent map segments (not to scale).

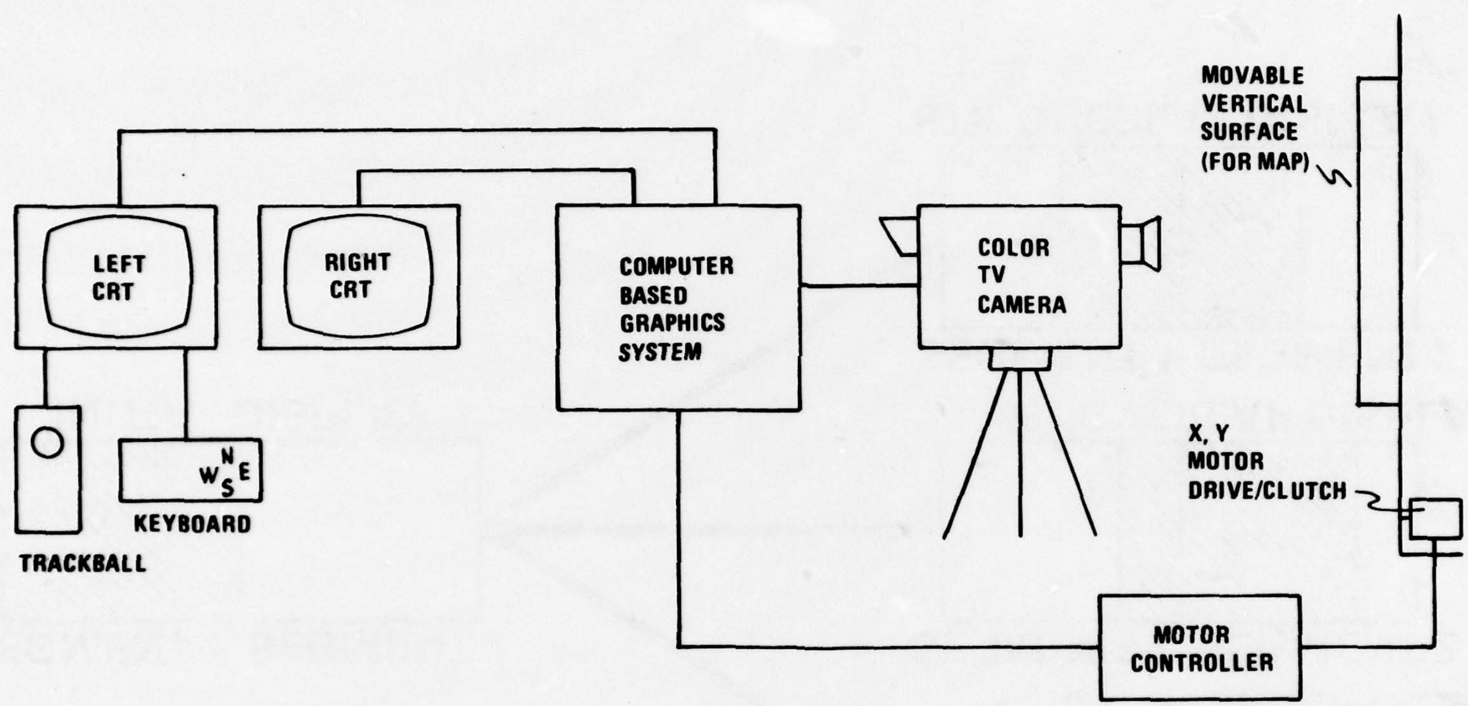


Figure 2. Block diagram of major apparatus components.

Figure 3. Work station with two CRTs, intercom, trackball, and special keyboard.

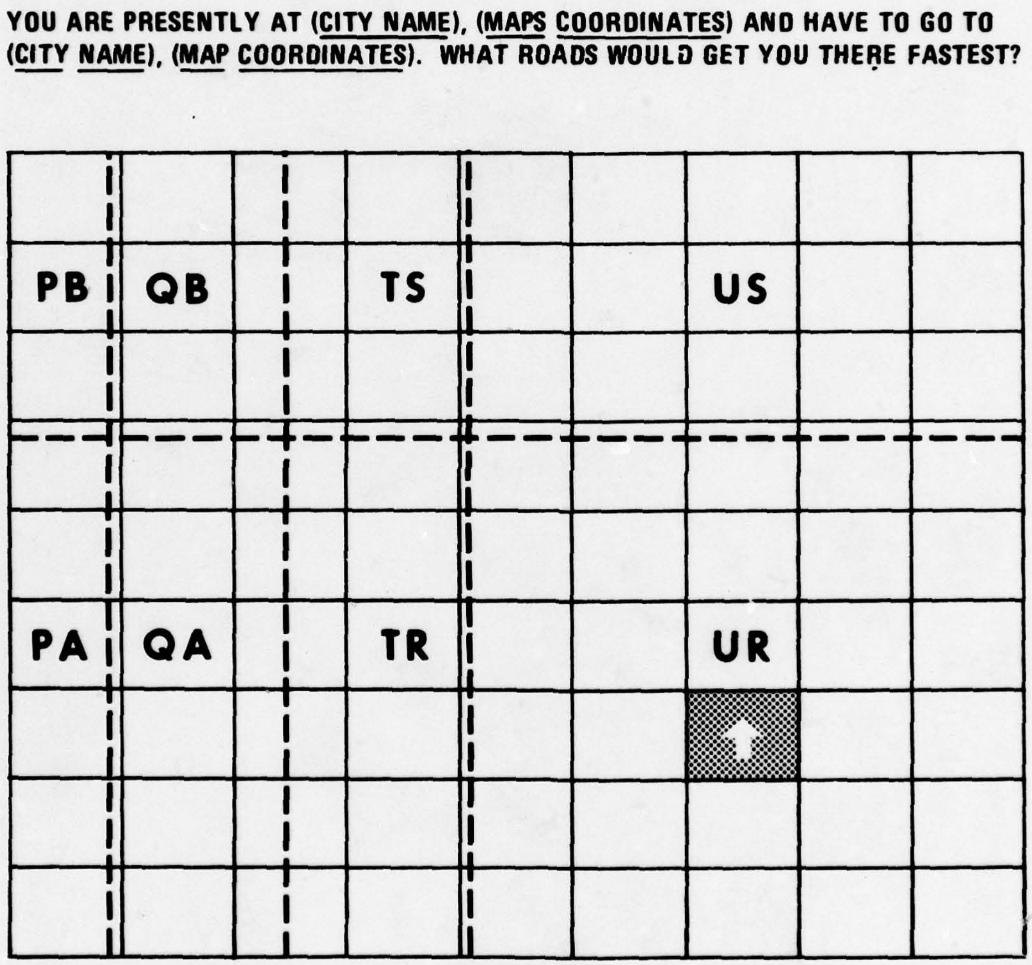


Figure 4. Right-hand CRT display (not to scale). (The darkened rectangle represents a 0% overlapping condition.)

Procedure

Participants read instructions which explained the task, introduced the CRT displays, reviewed the UTM coordinate system for the specific map area, and required practice on techniques necessary for solving problems. Participants also had a description of a general tactical situation that provided a context for the route selection problems. As part of the instructions, participants learned how to pursue a problem solution by marking road routes on the displayed map and changing segments as necessary. They used a trackball-guided cursor, appearing on the map display, to mark each black dot along a chosen route with a computer-generated green asterisk. Green asterisks could be replaced ("erased") by a red asterisk to show that a spot had been abandoned. Participants were instructed to mark only the black dots on red (primary) and red-dashed (secondary) roads when indicating problem solutions.

Participants controlled map changes by using four direction keys (N, S, E, W) on a specially marked keyboard (see Figure 2). Entering "N," for example, was a request to look at the map north of the current display. Angular moves were not allowed. The map board in front of the TV camera moved for both the continuous and discrete methods for changing map displays. The map was always readable for continuous displays. However, between discrete map presentations, while the map was moving, the display was completely covered by a computer-generated blue mask. The computer limited the amount of change during discrete methods, whereas for continuous changes, participants controlled starting and stopping of the map. Participants were told what change method would be used for a problem set and, as appropriate, the percentage overlap for a discrete method.

The apparatus caused a delay of about 8 seconds between map changes in the discrete presentations; a similar wait after a move request in the continuous method insured that the 8-second interval was constant for all change methods. The delay in changing segments may have strained the participants' immediate memory, but it was considered reasonable for laboratory evaluation of a map display system.

The research session for each participant lasted between 4 and 7 hours with rest and lunch breaks. Participants could report equipment malfunctions by using the participant-experimenter intercom.

Performance Measures

Performance measures for each problem were (a) time to solution, (b) number of map changes, and (c) quality of route selected. The solution time equaled the overall time for a problem solution minus the time spent waiting for new map information to appear. Times when the screen was blacked out during map changes by discrete methods were not considered to be part of solution time. For continuous scanning, the time that the map could be viewed while it was moving was part of solution time. Number of

map changes equaled participant requests to move the map in any of the four available directions. Quality of solution was determined by comparing points in a participant's solution with points in an "ideal" solution selected by computer algorithm (Cooper et al., 1974). The proportion of ideal points was used as the index of solution quality. The computer algorithm evaluated the fastest road sections between points in a network, including corrections for average travel speeds along different road types and the effects on travel speeds of city and terrain factors.

A final source of data was responses to a written questionnaire (Appendix B) that asked participants to evaluate research instructions, system operation, and task requirements. The questionnaire was given after a session was over and the project's purpose had been discussed.

RESULTS AND DISCUSSION

A user-efficient system for sequentially displaying maps should be accepted easily and should allow quick problem solutions of high quality. In the current research, user preferences for map change methods were not in perfect harmony with performance data. Results showed a first-place preference for continuous scanning of maps and a second-place preference for 25% overlapping segments. Performance data favored overlapping segments as most efficient. These differences were resolved by considering (a) performance data along with the solution strategies which generated them, (b) rationale for the preferences offered by participants, and (c) cost tradeoffs for system design. Conclusions were weighted toward optimizing user performance, since this could be done without any major effects on other criteria for an automated map change system.

Performance Data

Performance time and frequency of map changes varied systematically among the four map change methods (Table 1). In contrast, the quality of road route solutions remained consistent for the different map change methods. Analyses of variance (Tables 2 and 3), based on the Greco-Latin square design, showed significant performance differences for solution time ($F = 4.23$; $df = 3, 60$; $p < .01$) and for frequency of map changes ($F = 2.78$; $df = 3, 60$; $p < .05$). There also were significant small decreases in performance time over successive trials (i.e., learning effect) as well as significant differences in the difficulty of problem sets. Performance differences for trials and problem sets were unimportant, because the Greco-Latin square counterbalanced differences across presentation conditions.

An analysis of significant differences among means (Newmann Keuls Test) obtained for map changes and solution time revealed that (a) the number of map changes with 25% and 50% overlapping conditions is about 1.15 times greater than the number of changes with 0% overlap, and (b) the shortest solution time, by a factor of about .25, was produced by map

Table 1

Data Summary for Different Map Change Conditions

	MAP CHANGE CONDITIONS			
	0% DISCRETE	25% DISCRETE	50% DISCRETE	CONTINUOUS
SOLUTION TIME (IN SECS)	607.2	547.1	508.7	672.4
STANDARD DEVIATION	295.2	186.3	165.9	246.1
RANGE	1409.3	802.7	578.3	649.4
NO. OF MOVES	21.7	24.9	27.4	21.8
STANDARD DEVIATION	10.5	13.4	13.4	10.2
RANGE	34.7	45.7	48.3	39.7
SOLUTION QUALITY (PERCENT)	52.1	48.8	48.9	52.0
STANDARD DEVIATION	14.6	11.3	12.7	16.3
RANGE	51.7	42.5	43.5	71.4

Table 2

Analysis of Variance for Performance Time

Source of variation	Degrees of freedom	Mean square	F ratio	P
Between participants				
Group	3	137714	1.30	NS
Parts. within groups	20	105955		
Within participants				
Successive trials	3	88568	2.99	.05
Change methods	3	125262	4.23	.01
Message sets	3	248221	8.38	.001
Residual	3	76661	2.59	NS
Error	60	29610		
Total	95			

Table 3

Analysis of Variance for Frequency of Map Changes

Source of variation	Degrees of freedom	Mean square	F ratio	P
Between participants				
Group	3	385.43	1.12	NS
Parts. within groups	20	343.63		
Within participants				
Successive trials	3	23.52	.35	NS
Change methods	3	189.74	2.78	.05
Message sets	3	389.25	5.73	.001
Residual	3	87.53	1.29	NS
Error	60	67.98		
Total	95			

segments with 50% overlap (although data from segments with 25% overlap were not statistically different). Overall, an increase in the frequency of map changes necessary to solve a problem is associated with decreased problem solution times.

Frequency of map changes and time data can be stressed in the results only because the quality of route solutions remained consistent for all map change methods. However, the apparently low quality of route solutions, averaging only about 50%, requires some explanation. These findings are due to the rule used for obtaining results (see Appendix C), which did not include reasonable alternatives to an ideal solution. Routes that were similar or even parallel to the ideal route were numerous (Table 4) but were scored as incorrect. In addition, participants frequently marked a route compatible with the algorithm's solution and later erased it. Examples of routes are illustrated in Figure 5. Visual examination of solutions showed that participants preferred alternative routes to ideal routes for most problems. A check of solution time and travel time efficiency of selected ideal routes versus other routes revealed no consistent differences.

Performance Strategy

Performance strategy is a primary determinant of the time and number of map changes needed for solving problems. Participants appear to have used different strategies for the alternative map change methods. For example, solutions with the continuous map change method, in which users could scan new areas easily, were not expected to take as much time as with discrete methods. The problem-solving strategy most participants adopted, however, seemed to increase solution time. Participants spent much more time exploring possible routes during continuous scanning than during any discrete method. They first viewed large areas with a single map change, to try to locate the best route. Later, once a route definition was started, participants tended to move the map only far enough to keep the last marked point (green asterisk) in view. The outcome was few map changes, long performance times, and no improvement in the quality of problem solutions.

The strategies adopted by participants with the three discrete methods (0%, 25% and 50% overlap) also contributed to the resultant time and map change data. Participants exposed to the 25% and 50% overlap methods usually proceeded from the origin to the destination without first exploring the whole route. They would continue along a path as long as it proved useful, and when it stopped going in the right direction, they tried another route. Having any overlap usually enabled participants to keep at least one previously marked point (green asterisk) in view when they changed map segments. This seemed to provide sufficient orientation and allowed participants to make choices without having to search. Thus, with 50% overlap, less overall area was viewed than with 25% overlap, and for both these methods less overall area was viewed than for 0% overlap.

Table 4

Number of Participants Generating Ideal or Alternate Problem Solutions

	Problem solution frequency		
Problem sets	Ideal	Common alternative	Unique alternative
1	9	12	3
2	1	16; 5[a]	2
3	0	24	0
4	0	17	7
5	24	0	0
6	0	20; 2[a]	2
7	2	19	3
8	7	15	2
9	1	19	4
10	0	12; 10[a]	2
11	2	8; 5; 8[a]	1
12	24	0	0

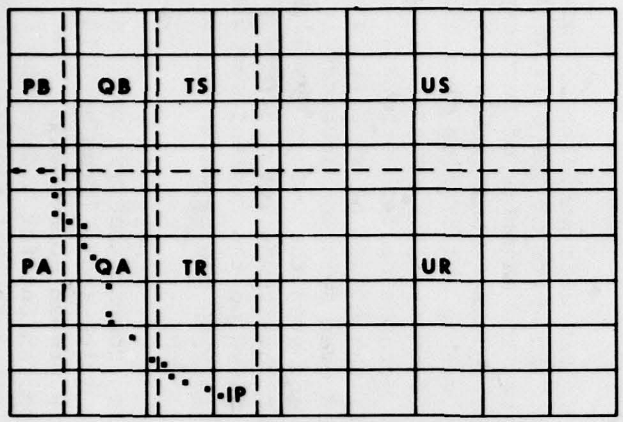
[a]Multiple entries refer to more than one common alternative for a problem solution.

In contrast, fewer moves were produced with 0% overlap than with either 25% or 50%. Of course, 0% overlap created a problem of memory and orientation, because a completely new area appeared with each move. Most participants dealt with the orientation problem by carefully studying a display of new information and sometimes reversing to view the previous segment. This reversing occurred mainly when a path was not obvious and the participant wished to check his work. Overall, results suggest that using a discrete method with overlap is important for minimizing time for problem solutions.

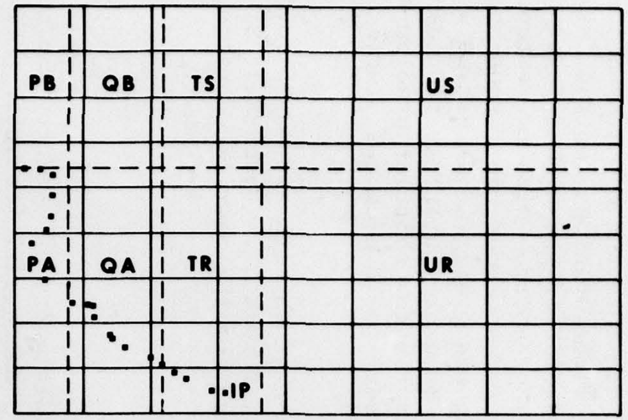
Participant Opinions

User opinion should be considered in selecting display system characteristics. A final source of data was the written questionnaire completed after the research by 24 participants. Responses showed that 19 participants preferred continuous scanning; 5 preferred discrete changes, 3 participants preferred discrete changes with 25% overlap; and 12 others made it their second choice. There was only one second choice preference for continuous scanning. Participants' comments indicated that continuous

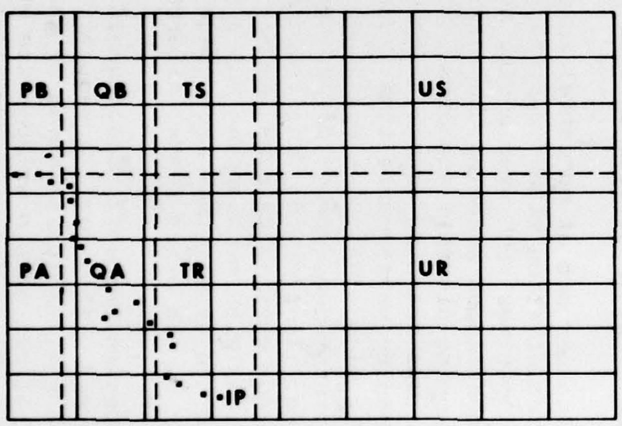
You know that supplies are being stockpiled at Saalburg, PA939983. You have been ordered to take Saalburg and capture/destroy the stockpiles. What roads would you take to get to your objective from your present location (vic) Asch, TR993678?



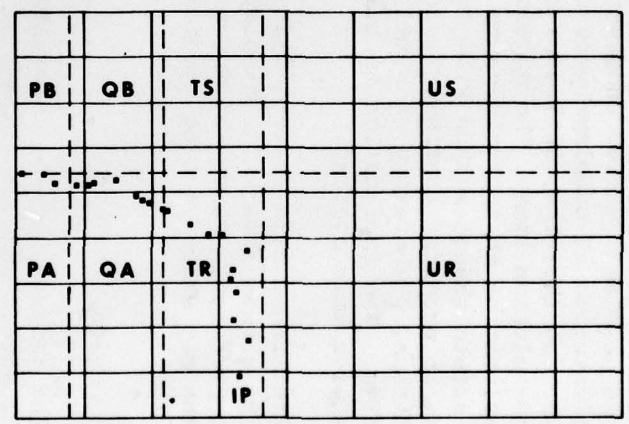
Ideal Solution (used by 9 participants)



Common Alternative *Solution*
(used by 12 participants)



Alternative Solution
(used by 2 participants)



Alternative Solution
(used by 1 participant)

Figure 5. Diagramed examples of solutions to problem one.

scanning provided quicker understanding of the relevant map area and easier orientation as displays were changed. These opinions contrast with data showing that the continuous method resulted in the highest average problem-solution time. The opinion agrees, of course, with the extensive map exploration that participants often performed under continuous changes. The discrete change method with 25% overlap was preferred almost as well because it provided continuity without too much or too little redundancy. In addition, 25% overlap resulted in a near tie for shortest problem-solution time. The implication is that many users could accept a discrete system with some overlap.

Preference data suggest that discrete changes with around 25% overlap would be a good choice for displaying map information. Nevertheless, the strong preference expressed for a system whereby the user can continuously scan the map should not be ignored.

System Design Tradeoffs

The results provide information that designers of military map change systems should consider in making tradeoffs among efficient user performance, equipment characteristics, and user satisfaction. One set of potential tradeoffs is between performance times and hardware requirements for changing map segments. The most cost-effective and durable hardware design probably would minimize the percentage of overlap and the number of changes needed to encompass a map. If designers use 25% as a guideline for overlapping segments, the demands on equipment should be reasonable without negative effects on user performance.

Another set of potential tradeoffs involves user performance versus user satisfaction with a map change system. In spite of the efficient performance times with overlapping map segments, the majority of participants made continuous scanning their first choice; their second choice was 25% overlapping discrete segments. The extensive map exploration possible with continuous scanning seemed to improve confidence in problem solutions while lengthening performance time. Users could perhaps be taught to work more rapidly with continuous scanning. However, the effect of such training on user preference, number of map changes, and even solution accuracy is uncertain. In addition, the training costs and even the system development costs for continuous scanning may be higher than those for discrete presentations with overlapping map segments. Based on the current research, a discrete system that uses about 25% overlapping map segments appears superior to the other tested alternatives.

Design tradeoffs also should take into account the type of task to be performed with a map. A request to find a quick route "from here to there" can be reasonably satisfied by sequentially presented segments. But a system that can skip over segments would be convenient for a user who has become familiar with a geographical area. In a task that requires studying of both map details and overviews, a system with zoom (i.e., change of scale) capability would be convenient.

A flexible map change system would help users determine the optimal sequence of travel among several cities and integrate scattered route details such as flood conditions and destroyed bridges. The required characteristics of a flexible system that would allow skipped segments and zooming need to be determined. One suggested method for selecting segments would be to use a UTM map reference system for calling up a location of interest; another way would be to use a number and letter grid similar to the locator system on many civilian maps. In a zoom system, map changes could be handled with either a discrete or a continuous display. Whatever the procedures, a system user should be allowed to select alternative map areas for viewing with different map scales. When sequential map changes of a constant scale are required, then overlapping segments are suggested as the display method.

CONCLUSION

To optimize user performance time, the designer of a map display system for military use should begin with discrete map segments that overlap by about 25%. The percentage can vary somewhat without affecting performance. The 25% guideline considers user preference but requires fairly frequent map changes, which increase demands on hardware. Performance criteria, user satisfaction, and equipment design all have a place in determining the most appropriate map display system.

REFERENCES

Berman, R., & Stonebreaker, M. GEO-QUEL--A System for the Manipulation and Display of Geographic Data. SIGGRAPH '77 Proceedings (published by Computer Graphics), 11, 1977, 186-191.

Cannon, B. Maps for Display Systems. Research and Development Technical Report No. 4147, U.S. Army Electronics Command, August 1973.

Cannon, B. Map Cassette for Data Display. Research and Development Technical Report No. 4501, U.S. Army Electronics Command, June 1977.

Carlson, E., Bennett, J., Giddings, G., & Mantey, P. The Design and Evaluation of an Interactive Geo-data Analysis and Display System. Proceedings IFIP Congress, 1974, 1057-1061.

Cooper, G., Moore, M., & Halpin, S. MOVANAID: An Analytic Aid for Army Intelligence Processing. Proceedings, Thirteenth Annual U.S. Army Operations Research Symposium, 1974, 696-707.

Granda, T. M. An Evaluation of Visual Search Behavior on a Cathode Ray Tube Utilizing the Window Technique. ARI Technical Paper 283, February 1978, (AD A05 3352).

Layman, R. S. An Experimental Comparison of Two Map Display Modes. Human Factors, 10(5), 1968, 497-503.

Moellering, H. Interactive Cartographic Design. American Congress on Surveying and Mapping Proceedings, 1977, 516-530.

Shimron, J. On Learning Maps. Center for Human Information Processing, UCLA, San Diego, Calif., (ARPA Order No. 2284), 1975.

Winer, B. J. Statistical Principles in Experimental Design (second ed.), New York: McGraw-Hill, 1971.

APPENDIX A

QUESTIONS USED IN RESEARCH

Practice Problem (repeated before each problem set)

You have been ordered to advance to the town of Falkenstein, UR135945, in preparation for an upcoming offensive. You are presently located at Oelsnitz, TR995892. Find the route that will get you to your new position the fastest.

Problem Set I

1. You know that supplies are being stockpiled at Saalburg, PA939983. You have been ordered to take Saalburg and capture/destroy the stockpiles. What roads would you take to get to your objective from your present location (vic) Asch, TR993678?

2. Your position has been tenuous. The OPFOR (Opposing Force) is advancing much more rapidly than expected. You must retreat from your present location at Georgen, UR202832, to the occupied town of Planitz, US220179. What roads would get you there the fastest?

3. Your BN has been reassigned from (vic) Oelsnitz (II), US375216, to (vic) Breitenbrunn, UR412939. You are to move out immediately by the fastest roads. Find them.

Problem Set II

4. A vital bridge at Elsterberg, TS998102, is being held by OPFOR. You have been assigned to retake the bridge. You are presently at Johanngeorgenstadt, UR386890. What roads would you take to get there the quickest?

5. Your unit has been assigned a supply mission to Tanna, QA034978. It is important that the supplies make their destination as soon as possible. What roads will accomplish this? Your present position is Luby, UR150701.

6. An important crossroads exists at Zeulenrod, QB108151. You have been tasked with protecting it. You are to move from Aue, US373064, by the quickest roads. Mark them.

Problem Set III

7. You are assigned to take part in an offensive on Reichenbach, US093113, at 0100 hours tomorrow. Your present location is Krajkova, UR243657. Find the roads you would take to reach the objective most quickly.

8. Your unit is presently assigned to Hirschberg, QA004877. New orders have been received reassigning you to Markneukirchen, UR102768. What roads would you take to get there in the shortest time?

9. You have been assigned to Schauenstein, PA950735, from your present position of Klingenthal, UR199815. What roads would you take to reach your destination as quickly as possible?

Problem Set IV

10. You have received orders to move from your present location at Zwickau, US232220, to (vic) Bramback, UR080666. What roads would get you there in the shortest time?

11. The 2nd Tank BN is being heavily pressed at Schonlind, QA114944. You are presently at Rehau, TR887707. What roads would you take to be able to reinforce the 2nd in the shortest amount of time?

12. An air drop of medical supplies is scheduled to be made to (vic) Moschlitz, PB945051. You are assigned to recover the supplies. Move from your present position of Werdau, US147226, to the drop point at Moschlitz as quickly as possible. What roads would you take?

APPENDIX B

AUTOMATED MAP DISPLAYS
POST-EXERCISE QUESTIONNAIRE

Your responses to the following questions will aid us in evaluating the approaches to map displays which you have worked with at the Army Research Institute.

1. Today's exercise ran for a number of hours during which you were required to undertake a series of tasks. Do you feel that your performance was adversely influenced by the factor of fatigue and that the time is too long to expect a user to operate with our system? Yes___No___
Comments:

____

____

____

2. Was the time for changing a map display overly long? Yes___No___
Comments:

____

____

____

3. Do you have any suggestions for improving the instructions?
Please comment:

____

____

____

4. Did you have sufficient time to learn to operate the system and generally become familiar with the contents and configuration of the map information? Yes___No___ Comments:

____

____

____

5. Did you have any "mechanical" problems with the task that seriously hampered your ability to obtain and manipulate the map information? (for example, getting information, using the keyboard, etc.) Yes____ No____ Comments:

6. Did you like the trackball as a device for interacting with the system? Yes___ No___ Comments:

7. Were the grid and the red locator box on the second display helpful? Yes___No___ Would you suggest any changes?

8. Was the UTM coordinate system adequate for use with the displayed maps? Yes___No___ What changes (if any) might you suggest for use with the displayed maps?

9. Were any problems too long (i.e., too many display changes)? Yes___No___ Comments:

10. Were the roads difficult to follow on the displayed maps? Yes___ No___ Comment on any bothersome aspects--if any.

11. What would you have liked the system to do for you that wasn't available in the present task?

12. Were the problems similar to those that an S3 might deal with in the real world? Yes___No___ In what ways?

Please comment as appropriate--There were two basically different map presentations in this research: slides versus continuous changes of the map display. Did you prefer one over the other? Why? Did the degree of overlap between adjacent slides affect your ability to use the map?

Please do not discuss details of your participation in this task with others who may work with us at a later date.

APPENDIX C

DISCUSSION OF ALTERNATIVE SCORING METHODS

The scoring method used in the present research to compare actual routes with ideal routes was not the only one that could have been devised. However, it allowed consistent evaluation of possible routes and strict comparisons among map change conditions.

Development of any method for scoring road routes is complicated by the traditional rationale used for route selection. Often an officer's choice of different routes depends on the nature of the mission assigned. If speed is essential, then the commander may decide to take risks which normally would be avoided. But, if safely arriving with needed reinforcements or supplies is the requirement, then a slower, more secure route might be chosen. Although there are certain general principles which all military officers follow (e.g., avoid cities), the actual selection is based more on experience, knowledge of the overall situation, and intuition than on any hard and fast rules.

Individualized route solutions could be studied by using a multi-attitudinal or multi-dimensional approach. This would break the solutions down into their component parts and provide an idea of which components are most important. However, the integration of data into "textbook" solutions would be difficult and would represent a questionable basis for scoring performance.

Scoring rules in the present research focused on determining the fastest route because this was the primary performance requirement. However, this requirement did not simplify scoring. Consider that the fastest route is not necessarily the shortest route; differences in road quality can significantly affect speed of travel. For example, a unit traveling a longer distance on a primary road can reach a destination more quickly than a similar unit traveling on a secondary road. Thus, length of route taken, one possible scoring rule for the problems, is inadequate.

Another possible scoring method would be to compare travel time instead of travel routes. The computer algorithm used as a criterion in the research can determine the shortest time a unit would take to travel from an origin to a destination. Travel times for routes chosen by participants could be calculated and compared to the "ideal" time. However, each unique route segment requires separate time calculations, which can become voluminous. Whereas travel time calculations are practical for sampling different solutions, they are not practical for an exhaustive treatment of the data without specially designed software.

DISTRIBUTION

ARI Distribution List

4 OASD (M&RA)
2 HQDA (DAMI-CSZ)
1 HQDA (DAPE-PBR)
1 HQDA (DAMA-AR)
1 HQDA (DAPE-HRE-PO)
1 HQDA (SGRD-ID)
1 HQDA (DAMI-DOT-C)
1 HQDA (DAPC-PMZ-A)
1 HQDA (DACH-PPZ-A)
1 HQDA (DAPE-HRE)
1 HQDA (DAPE-MPO-C)
1 HQDA (DAPE-DW)
1 HQDA (DAPE-HRL)
1 HQDA (DAPE-CPS)
1 HQDA (DAFD-MFA)
1 HQDA (DARD-ARS-P)
1 HQDA (DAPC-PAS-A)
1 HQDA (DUSA-OR)
1 HQDA (DAMO-RQR)
1 HQDA (DASG)
1 HQDA (DA10-PI)
1 Chief, Consult Div (DA-OTSG), Adelphi, MD
1 Mil Asst. Hum Res, ODDR&E, OAD (E&LS)
1 HQ USARAL, APO Seattle, ATTN: ARAGP-R
1 HQ First Army, ATTN: AFKA-OI-TI
2 HQ Fifth Army, Ft Sam Houston
1 Dir, Army Stf Studies Ofc, ATTN: OAVCSA (DSP)
1 Ofc Chief of Stf, Studies Ofc
1 DCSPER, ATTN: CPS/OCP
1 The Army Lib, Pentagon, ATTN: RSB Chief
1 The Army Lib, Pentagon, ATTN: ANRAL
1 Ofc, Asst Sect of the Army (R&D)
1 Tech Support Ofc, OJCS
1 USASA, Arlington, ATTN: IARD-T
1 USA Rsch Ofc, Durham, ATTN: Life Sciences Dir
2 USARIEM, Natick, ATTN: SGRD-UE-CA
1 USATTC, Ft Clayton, ATTN: STETC-MO-A
1 USAIMA, Ft Bragg, ATTN: ATSU-CTD-OM
1 USAIMA, Ft Bragg, ATTN: Marquat Lib
1 US WAC Ctr & Sch, Ft McClellan, ATTN: Lib
1 US WAC Ctr & Sch, Ft McClellan, ATTN: Tng Dir
1 USA Quartermaster Sch, Ft Lee, ATTN: ATSM-TE
1 Intelligence Material Dev Ofc, EWL, Ft Holabird
1 USA SE Signal Sch, Ft Gordon, ATTN: ATSO-EA
1 USA Chaplain Ctr & Sch, Ft Hamilton, ATTN: ATSC-TE-RD
1 USATSCH, Ft Eustis, ATTN: Educ Advisor
1 USA War College, Carlisle Barracks, ATTN: Lib
2 WRAIR, Neuropsychiatry Div
1 DLI, SDA, Monterey
1 USA Concept Anal Agcy, Bethesda, ATTN: MOCA-MR
1 USA Concept Anal Agcy, Bethesda, ATTN: MOCA-JF
1 USA Arctic Test Ctr, APO Seattle, ATTN: STEAC-PL-MI
1 USA Arctic Test Ctr, APO Seattle, ATTN: AMSTE-PL-TS
1 USA Armament Cmd, Redstone Arsenal, ATTN: ATSK-TEM
1 USA Armament Cmd, Rock Island, ATTN: AMSAR-TDC
1 FAA-NAFEC, Atlantic City, ATTN: Library
1 FAA-NAFEC, Atlantic City, ATTN: Human Engr Br
1 FAA Aeronautical Ctr, Oklahoma City, ATTN: AAC-44D
2 USA Fld Arty Sch, Ft Sill, ATTN: Library
1 USA Armor Sch, Ft Knox, ATTN: Library
1 USA Armor Sch, Ft Knox, ATTN: ATSB-DI-E
1 USA Armor Sch, Ft Knox, ATTN: ATSB-DT-TP
1 USA Armor Sch, Ft Knox, ATTN: ATSB-CD-AD
2 HQUSACDEC, Ft Ord, ATTN: Library
1 HQUSACDEC, Ft Ord, ATTN: ATEC-EX-E-Hum Factors
2 USAEEC, Ft Benjamin Harrison, ATTN: Library
1 USAPACDC, Ft Benjamin Harrison, ATTN: ATCP-HR
1 USA Comm-Elect Sch, Ft Monmouth, ATTN: ATSN-EA
1 USAEC, Ft Monmouth, ATTN: AMSEL-CT-HDP
1 USAEC, Ft Monmouth, ATTN: AMSEL-PA-P
1 USAEC, Ft Monmouth, ATTN: AMSEL-SI-CB
1 USAEC, Ft Monmouth, ATTN: C, Facl Dev Br
1 USA Materials Sys Anal Agcy, Aberdeen, ATTN: AMXSY-P
1 Edgewood Arsenal, Aberdeen, ATTN: SAREA-BL-H
1 USA Ord Ctr & Sch, Aberdeen, ATTN: ATSL-TEM-C
2 USA Hum Engr Lab, Aberdeen, ATTN: Library/Dir
1 USA Combat Arms Tng Bd, Ft Benning, ATTN: Ad Supervisor
1 USA Infantry Hum Rsch Unit, Ft Benning, ATTN: Chief
1 USA Infantry Bd, Ft Benning, ATTN: STEBC-TE-T
1 USASMA, Ft Bliss, ATTN: ATSS-LRC
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA CTD ME
1 USA Air Def Sch, Ft Bliss, ATTN: Tech Lib
1 USA Air Def Bd, Ft Bliss, ATTN: FILES
1 USA Air Def Bd, Ft Bliss, ATTN: STEBD-PO
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: Lib
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: ATSW-SE-L
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: Ed Advisor
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: DepCdr
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: CCS
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCASA
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACO-E
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACC-CI
1 USAECOM, Night Vision Lab, Ft Belvoir, ATTN: AMSEL-NV-SD
3 USA Computer Sys Cmd, Ft Belvoir, ATTN: Tech Library
1 USAMERDC, Ft Belvoir, ATTN: STSFB-DQ
1 USA Eng Sch, Ft Belvoir, ATTN: Library
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL-TD-S
1 USA Topographic Lab, Ft Belvoir, ATTN: STINFO Center
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL-GSL
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: CTD-MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATS-CTD-MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-TE
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-TEX-GS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-CTS-OR
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-CTD-DT
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-CTD-CS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: DAS/SRD
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-TEM
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: Library
1 CDR, HQ Ft Huachuca, ATTN: Tech Ref Div
2 CDR, USA Electronic Prvg Grd, ATTN: STEEP-MT-S
1 HQ, TCATA, ATTN: Tech Library
1 HQ, TCATA, ATTN: AT CAT-OP-Q, Ft Hood
1 USA Recruiting Cmd, Ft Sheridan, ATTN: USARCPM-P
1 Senior Army Adv., USAFAGOD/TAC, Elgin AF Aux Fld No. 9
1 HQ, USARPAC, DCSPER, APO SF 96558, ATTN: GPPE-SE
1 Stimson Lib, Academy of Health Sciences, Ft Sam Houston
1 Marine Corps Inst., ATTN: Dean-MCI
1 HQ, USMC, Commandant, ATTN: Code MTMT
1 HQ, USMC, Commandant, ATTN: Code MPI-20-28
2 USCG Academy, New London, ATTN: Admission
2 USCG Academy, New London, ATTN: Library
1 USCG Training Ctr, NY, ATTN: CO
1 USCG Training Ctr, NY, ATTN: Educ Svc Ofc
1 USCG, Psychol Res Br, DC, ATTN: GP 1/62
1 HQ Mid-Range Br, MC Det, Quantico, ATTN: P&S Div

1 US Marine Corps Liaison Ofc, AMC, Alexandria, ATTN: AMCGS-F
1 USATRADOC, Ft Monroe, ATTN: ATRO-ED
6 USATRADOC, Ft Monroe, ATTN: ATPR-AD
1 USATRADOC, Ft Monroe, ATTN: ATTS-EA
1 USA Forces Cmd, Ft McPherson, ATTN: Library
2 USA Aviation Test Bd, Ft Rucker, ATTN: STEBG-PO
1 USA Agcy for Aviation Safety, Ft Rucker, ATTN: Library
1 USA Agcy for Aviation Safety, Ft Rucker, ATTN: Educ Advisor
1 USA Aviation Sch, Ft Rucker, ATTN: PO Drawer O
1 HQUSA Aviation Sys Cmd, St Louis, ATTN: AMSAV-ZDR
2 USA Aviation Sys Test Act., Edwards AFB, ATTN: SAVTE-T
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA TEM
1 USA Air Mobility Rsch & Dev Lab, Moffett Fld, ATTN: SAVDL-AS
1 USA Aviation Sch, Res Tng Mgt, Ft Rucker, ATTN: ATST-T-RTM
1 USA Aviation Sch, CO, Ft Rucker, ATTN: ATST-D-A
1 HQ, DARCOM, Alexandria, ATTN: AMXCD-TL
1 HQ, DARCOM, Alexandria, ATTN: CDR
1 US Military Academy, West Point, ATTN: Serials Unit
1 US Military Academy, West Point, ATTN: Ofc of Milt Ldrshp
1 US Military Academy, West Point, ATTN: MAOR
1 USA Standardization Gp, UK, FPO NY, ATTN: MASE-GC
1 Ofc of Naval Rsch, Arlington, ATTN: Code 452
3 Ofc of Naval Rsch, Arlington, ATTN: Code 458
1 Ofc of Naval Rsch, Arlington, ATTN: Code 450
1 Ofc of Naval Rsch, Arlington, ATTN: Code 441
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Acous Sch Div
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Code L51
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Code L5
1 Chief of NavPers, ATTN: Pers-OR
1 NAVAIRSTA, Norfolk, ATTN: Safety Ctr
1 Nav Oceanographic, DC, ATTN: Code 6251, Charts & Tech
1 Center of Naval Anal, ATTN: Doc Ctr
1 NavAirSysCom, ATTN: AIR-5313C
1 Nav BuMed, ATTN: 713
1 NavHelicopterSubSqua 2, FPO SF 96601
1 AFHRL (FT) Williams AFB
1 AFHRL (TT) Lowry AFB
1 AFHRL (AS) WPAFB, OH
2 AFHRL (DOJZ) Brooks AFB
1 AFHRL (DOJN) Lackland AFB
1 HQUSAF (INYSD)
1 HQUSAF (DPXXA)
1 AFVTG (RD) Randolph AFB
3 AMRL (HE) WPAFB, OH
2 AF Inst of Tech, WPAFB, OH, ATTN: ENE/SL
1 ATC (XPTD) Randolph AFB
1 USAF AeroMed Lib, Brooks AFB (SUL-4), ATTN: DOC SEC
1 AFOSR (NL), Arlington
1 AF Log Cmd, McClellan AFB, ATTN: ALC/DPCRB
1 Air Force Academy, CO, ATTN: Dept of Bel Scn
5 NavPers & Dev Ctr, San Diego
2 Navy Med Neuropsychiatric Rsch Unit, San Diego
1 Nav Electronic Lab, San Diego, ATTN: Res Lab
1 Nav TrngCen, San Diego, ATTN: Code 9000-Lib
1 NavPostGraSch, Monterey, ATTN: Code 55Aa
1 NavPostGraSch, Monterey, ATTN: Code 2124
1 NavTrngEquipCtr, Orlando, ATTN: Tech Lib
1 US Dept of Labor, DC, ATTN: Manpower Admin
1 US Dept of Justice, DC, ATTN: Drug Enforce Admin
1 Nat Bur of Standards, DC, ATTN: Computer Info Section
1 Nat Clearing House for MH-Info, Rockville
1 Denver Federal Ctr, Lakewood, ATTN: BLM
12 Defense Documentation Center
4 Dir Psych, Army Hq, Russell Ofcs, Canberra
1 Scientific Advsr, Mil Bd, Army Hq, Russell Ofcs, Canberra
1 Mil and Air Attache, Austrian Embassy
1 Centre de Recherche Des Facteurs, Humaine de la Defense Nationale, Brussels
2 Canadian Joint Staff Washington
1 C/Air Staff, Royal Canadian AF, ATTN: Pers Std Anal Br
3 Chief, Canadian Def Rsch Staff, ATTN: C/CRDS(W)
4 British Def Staff, British Embassy, Washington
1 Def & Civil Inst of Enviro Medicine, Canada
1 AIR CRESS, Kensington, ATTN: Info Sys Br
1 Militaerpsykologisk Tjeneste, Copenhagen
1 Military Attache, French Embassy, ATTN: Doc Sec
1 Medecin Chef, C.E.R.P.A.-Arsenal, Toulon/Naval France
1 Prin Scientific Off, Appl Hum Engr Rsch Div, Ministry of Defense, New Delhi
1 Pers Rsch Ofc Library, AKA, Israel Defense Forces
1 Ministeris van Defensie, DOOP/KL Afd Sociaal Psychologische Zaken, The Hague, Netherlands